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(56) Documents to be considered in evaluating patentability:

US 5,207,932
EP 208,682 B1
EP 311,670 A2
WO 92-15,371 A1
WO 92 12,764 A1

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(54) Title of the Invention:

FOAM CONCENTRATE AND FIRE-EXTINGUISHING AGENT PRODUCED FROM IT

The following information is derived from documents submitted by the applicant.

S P E C I F I C A T I O N

The invention concerns a foam fire-extinguishing agent. Foam is an indispensable extinguishing agent for fires of classes A and B for fighting fires with the use of a liquid foam extinguishing agent based on a foam concentrate. Foam is composed of water, the foam concentrate, and air.

In the case of fire class B, fires of foam-destroying liquids can be extinguished only with the use of certain special foam concentrates. Foam-destroying liquids are essentially polar liquids that dissolve the foam.

These special foam concentrates are referred to as alcohol-resistant foam concentrates (ARC) due to the ability of the foams produced from them to extinguish alcohol fires. The characteristic components of ARC's are water-soluble polymers, usually polysaccharides of the xanthan gum type (which we shall refer to simply as xanthan gum), which form a solid layer of polymer on fires of foam-destroying liquids. The polymer layer spreads out over the surface of the liquid and protects the foam from destruction. Xanthan gum is a polysaccharide secreted by the bacterium *Xanthomonas campestris*.

The foam concentrate is mixed with water in concentrations of 3-6 wt.%, depending on the type of concentrate, and the foam is produced with the use of suitable foam tubes. The other components in

(a) ARC's based on synthetic surfactants are hydrocarbon surfactants, fluorinated surfactants, glycols, and glycol ethers, and in

(b) ARC's based on hydrolyzed protein produced by digestion of protein carriers are metal salts, usually fluorinated surfactants, and various foam stabilizers.

When fluorinated surfactants are used, the foam forms an aqueous film on nonpolar combustibles that are not foam-destroying. The film spreads out over

bles (so-called film formation).

Since type (a) has by far the greater importance, we shall be concerned to discuss foam concentrates of this type.

Foam concentrates of type (a) must be mixed with water in amounts of at least 3 wt.% for use on alcohol fires. Until a few years ago, the only foam concentrates that were known had to be mixed in amounts of at least 5 wt.% for use on fires of foam-destroying liquids. Foam concentrates were later developed which were approved for extinguishing fires of foam-destroying liquids in concentrations of only 3 wt.%. We shall refer to these types of concentrates as ARC 3 × 3.

The general disadvantage of ARC 3 × 3 concentrates is their high viscosity. To be able to create a stable polymer layer when extinguishing fires of foam-destroying liquids, the foam concentrate must contain a certain minimum concentration of water-soluble polymer. This very high concentration significantly reduces the fluidity of the foam concentrate. The foam concentrate is a non-Newtonian fluid, i.e., the viscosity depends on the state of motion of the fluid. In practice, this means that, especially at low temperatures, the mixing of the foam concentrate with the extinguishing water presents problems in mixing systems that do not have mechanically forced mixing, so that the minimum mixing concentration necessary to achieve a reliable extinguishing capacity is not assured.

So far, the following approaches have been taken to solve this problem:

The viscosity of ARC 3 × 3 concentrates is reduced by the addition of an excess of 2,2'-butoxyethoxy)ethanol or certain water-soluble anionic polymers. Of course, this is accomplished at the expense of the aging stability of the foam concentrate. After completion of the thermal cycling test in ac-

the foam concentrate container, which cannot be used as a foam concentrate for producing extinguishing foam for extinguishing fires of foam-destroying liquids.

2. Attempts to replace water-soluble polymers with liquid mixtures of solutions of certain fluorinated surfactants, e.g., amino acids with perfluoroalkyl radicals, resulted in very low viscosities but failed to achieve reliable extinguishing capacity on polar liquids in accordance with DIN 14,272.

3. The necessary concentration of polymer was also reduced by addition of alkyl mono-, oligo-, and/or polyglucosides, which lowered the viscosity.

Alkyl glucosides also interact with the xanthan gum, probably by condensation polymerization, so that a positive effect on the stability of the polymer layer and thus on the extinguishing capacity of the foam is to be expected and can also be achieved to a certain extent. However, it was not previously known which specific alkyl mono-, alkyl oligo-, or alkyl polyglucoside produces the most distinct advantages for these purposes.

The goal of the invention was to find a specific alkyl mono-, alkyl oligo- or alkyl polyglucoside which optimizes the extinguishing capacity of the foam and lowers the viscosity. This goal is achieved with a foam concentrate with the following composition:

A distilled water,

B ethylene glycol,

C [illegible] butoxyethoxy ethanol,

D fluorinated surfactant solution that has a film forming effect,

E fluorinated surfactant solution that does not have a film forming effect,

F hydrocarbon surfactant solution,

H xanthan gum.

It was found that the alkyl monoglucoside solution enters into an optimum interaction with a polysaccharide, e.g., xanthan gum.

Characteristic properties are

a) for steric reasons, the chain length of the alkyl radical on the glucoside in (G) may not be too long (C8 and C10);

b) the same chain length of the alkyl radicals of the hydrocarbon surfactant in (F) and of the alkyl glucoside in (G) produce constructive interaction; and

c) for steric reasons, a more effective interaction with the xanthan gum is achieved with alkyl monoglucosides than with alkyl oligo- or polyglucosides.

Consequently, the foam concentrate ARC 3 × 3 is optimized with respect to reduction of the viscosity and improvement of the extinguishing characteristics.

The foam concentrate of the invention has the following advantages:

1. The time required for the foam to extinguish the flames of an isopropanol fire is only about 50% compared to foams based on foam concentrates that do not contain the specified alkyl monoglucosides but do contain other alkyl glucosides.

2. The xanthan gum content can be reduced to about 40% without reducing the extinguishing capacity.

3. It is makes it possible to lower the viscosity almost to that of polymer-free foam concentrates.

4. Due to the low viscosity and the low crystallization temperature, the foam concentrate theoretically can be mixed without forced mixing, even at

Example 1

The aqueous foam extinguishing agent has the following composition:

1.140% distilled water,

6.66% ethylene glycol,

0.150% 2-(2'-butoxyethoxy)ethanol,

0.420% fluorinated surfactant solution that has a film-forming effect,

0.105% fluorinated surfactant solution that does not have a film-forming effect,

0.345% hydrocarbon surfactant solution,

0.135% alkyl monoglucoside solution,

0.045% xanthan gum, and

97% extinguishing water.

(Note 1: Here and below, all values in wt.%; the mass of the air contained in the foam is disregarded.)

(Note 2: The fluorinated surfactant solution that has a film-forming effect is commercially available, e.g., under the name Light Water FC-3041 AFFF.)

The extinguishing agent is produced by diluting a foam concentrate to 3 wt.% in water. Testing in accordance with DIN 14,272 yielded the following results:

Foaming number (L/kg): 10.5

Water melt life (minutes): 25

Surface tension (mN/m): 18.5

Interfacial tension against cyclohexane (hereinafter: interfacial tension (mN/m): 1.5

Melting point of the foam concentrate (°C): -19.5

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at 20°C, capillary tube with factor 5.023: 90-160

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at -15°C, capillary tube with factor 5.023: 3,370

Extinguishing capacity in a 4-m² tank in accordance with DIN 14,272, 300 L of isopropyl alcohol, preburning time 120 s, application rate 5.7 L/m²•min

90% check (s): 50

Extinguishing time (s): 55

Resistance to reignition: 10 minutes after placement of the reignition vessel, no signs of reappearance of flames could be observed.

One liter of the foam concentrate was subjected to a thermal cycling test in accordance with DIN 14,272 to simulate a foam concentrate aging process. The foam concentrate was then tested as described above.

Foaming number (L/kg): 10.6

Water half-life (minutes): 25

Surface tension (mN/m): 18.3

Interfacial tension (mN/m): 1.8

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at 20°C, capillary tube with factor 5.023: 150

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at -15°C, capillary tube with factor 5.023: 3,130.

Example 1

The aqueous foam extinguishing agent has the following composition:

1.209% distilled water,

[illegible]% ethylene glycol,

0.420% fluorinated surfactant solution that has a film-forming effect,

0.168% fluorinated surfactant solution that does not have a film-forming effect,

0.270% hydrocarbon surfactant solution,

0.210% alkyl monoglucoside solution,

0.021% xanthan gum, and

97% extinguishing water.

The extinguishing agent is produced by diluting a foam concentrate to 3 wt.% in water. Testing in accordance with DIN 14,272 yielded the following results:

Foaming number (L/kg): 9.5

Water half-life (minutes): 15

Melting point of the foam concentrate (°C): -20.5

pH of the foam concentrate: 6.5-7.5

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at 20°C, capillary tube with factor 5.023: 2,700-2,800

Extinguishing capacity in a 4-m² tank in accordance with DIN 14,272, 300 L of isopropyl alcohol, 120 s preburning time, application rate 5.7 L/m²•min

90% check (s): 47

Extinguishing time (s): 54

Resistance to reignition: 10 minutes after placement of the reignition vessel, an area of about 10% (based on 4 m²) burned at the edge of the reign[illegible]

Example 3

The aqueous foam extinguishing agent has the following composition:

[illegible] distilled water,

0.147% 2-(2'-butoxyethoxy ethanol,

0.420% fluorinated surfactant solution that has a film-forming effect,

0.105% fluorinated surfactant solution that does not have a film-forming effect,

0.345% hydrocarbon surfactant solution,

0.180% alkyl monoglucoside solution,

0.021% xanthan gum, and

97% extinguishing water.

The extinguishing agent is produced by diluting a foam concentrate to 3 wt.% in water. Testing in accordance with DIN 14272 yielded the following results:

Foaming number (L/kg): 9.5

Water half-life (minutes): 15

Surface tension (mN/m): 18.5

Interfacial tension (mN/m): 1.5

pH of the foam concentrate: 6.5-7.5

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at 20°C, capillary tube with factor 0.0975: 27-36

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at 0°C, capillary tube with factor 0.0975: 80-90

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at -15°C, capillary tube with factor 0.0975: 220-310

Extinguishing capacity in a 4-m² tank in accordance with DIN 14272, 300 L of isopropyl alcohol, 120 s preburning time, application rate 5.7 L/m²·min

90% check (s): 55

Extinguishing time (s): 62

Resistance to reignition: 10 minutes after placement of the reignition

tion vessel.

Mixability

The foam concentrate was maintained at -10°C for 24 h. The effective mixing of the cooled foam concentrate was then determined with a DIN mixer, type Z 1, calibrated with water to 3%. The effective mixing was 3.0%.

One liter of the foam concentrate was subjected to a thermal cycling test in accordance with DIN 14272 to simulate a foam concentrate aging process. The foam concentrate was then tested as described above.

Foaming number (L/kg): 10.0

Water half-life (minutes): 17

Surface tension (mN/m): 17.8

Interfacial tension (mN/m): 1.8

Relative kinematic viscosity of the foam concentrate according to Ubbelohde [mm²/s)] at 20°C, capillary tube with factor 0.0975: 30

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm²/s) at 0°C, capillary tube with factor 0.0975: 89.

Example 4

The aqueous foam extinguishing agent has the following composition:

[illegible]% distilled water,

[illegible]% ethylene glycol,

[illegible]% 2-(2-butoxyethoxy) ethanol,

0.6[illegible]% fluorinated surfactant solution that has a film forming effect,

0.09% fluorinated surfactant solution that does not have a film-forming effect.

3.135% alkyl monoglucoside solution,

0.045% xanthan gum, and

97% extinguishing water.

The extinguishing agent is produced by diluting a foam concentrate to 3 wt.% in water. Testing in accordance with DIN 14,272 yielded the following results:

Foaming number (L/kg): 10.0

Water half-life (minutes): 28

Melting point of the foam concentrate (°C): -20.5

pH of the foam concentrate: 6.5-7.5

Relative kinematic viscosity of the foam concentrate according to Ubbelohde (mm^2/s) at 20°C, capillary tube with factor 5.023: 1,200-1,700.

CLAIM(S)

1. A foam concentrate for fire-extinguishing purposes, which has the following composition:

(A) distilled water,

(B) ethylene glycol,

(C) 2-(2'-butoxyethoxy)ethanol,

(D) fluorinated surfactant solution that has a film-forming effect,

(E) fluorinated surfactant solution that does not have a film-forming effect,

(F) hydrocarbon surfactant solution,

(G) alkyl monoglucoside solution, and

(H) xanthan gum.

2. Foam concentrate in accordance with Claim 1, characterized by the fact that the components have the following compositions:

(B) ethylene glycol, > 99%

(C) 2,-(2'-butoxyethoxy)ethanol, > 99%

(D) a fluorinated surfactant solution that has a film-forming effect, with the following composition:

36% 2-(2'-butoxyethoxy)ethanol,

36% distilled water,

15-20% fluoroaliphatic surfactant,

[illegible] synthetic surfactant

(E) a fluorinated surfactant solution that does not have a film forming effect, with the following composition:

[illegible] distilled water,

[illegible] 1,1 dimethylethanol,

[illegible] of the molecule with the following formula:

$$R_f-CH_2-CH_2-S-[CH_2-CHCOOH-]_x-[CH_2-CHCONH_2-]_y-H$$

where R_f is a spectrum of perfluoroalkyl radicals from C_6F_{13} to $C_{14}F_{29}$ with a maximum at C_8F_{17} and x + y = 30 and x/(x + y) = 0.2, [*This is rather goofy, since this means x = 6 and y = 24, so why bother with the x and y if they are constants and not variables? -- Tr. Ed.*]

(F) the hydrocarbon surfactant solution with the following composition:

59% water,

23% sodium *n*-decyl sulfate,

18% sodium *n*-octyl sulfate

(G) the alkyl monoglucoside solution with the following composition:

24-27% *n*-octyl-α-D-glucoside,

24-27% *n*-decyl-α-D-glucoside,

48-54% water

(H) the xanthan gum with a maximum of the grain-size distribution at 180 μm.

3. Use of the foam concentrate in accordance with Claims 1 and 2, with the following composition:

30-40% distilled water,

5-25% ethylene glycol,

0-10% 2-(2'-butoxyethoxy)ethanol,

10-29% fluorinated surfactant solution that has a film-forming effect,

1-5% fluorinated surfactant solution that does not have a film-forming effect,

1-10% hydrocarbon surfactant solution,

2-15% alkyl monoglucoside solution,

0.2-1.7% xanthan gum,

such that 3-5 wt.% of the foam concentrate is combined with 95-97 wt.% of ex